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Investing in Skilled Specialists to Grow Hospital Infrastructure for Quality Improvement

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Objectives: Hospitals can reduce labor costs by hiring lowest skill possible for the job, stretching clinical hours, and reducing staff not at bedside. However, these labor constraints designed to reduce costs may paradoxically increase costs. Specialty staff, such as board-certified clinicians, can redesign health systems to evaluate the needs of complex patients and prevent complications. The aim of the study was to evaluate whether investing in skilled specialists for supporting hospital quality infrastructure improves value and performance.

Methods: We evaluated pressure injury rates as an indicator of performance in a retrospective observational cohort of 55 U.S. academic hospitals from the Vizient clinical database between 2007 and 2012. Pressure injuries were defined by U.S. Agency for Healthcare Research and Quality (AHRQ) Patient Safety Indicator 3 (PSI-03) for stage 3, 4, and unstageable pressure injuries not present on admission in hospitalized adults. We compared ratios of board-certified wound care nurses per 1000 hospital beds to hospital-acquired pressure injury rates in these hospitals using mixed-effects regression of hospital quarters.

Results: High-performing hospitals invested in prevention infrastructure with skilled specialists and observed performance improvements. Regression indicated that by adding one board-certified wound care nurse per 1000 hospital beds, hospitals had associated decreases in pressure injury rates by −17.7% relative to previous quarters, controlling for other interruptions. Highest performers supplied fewer skilled specialists and achieve improved outcomes.

Conclusions: Skilled specialists bring important value to health systems as a representation of investment in infrastructure, and the proportion of these specialists could be scaled relative to the hospital's patient capacity. Policy should support hospitals to make investments in infrastructure to drive down patient costs and improve quality.

Key Words: health system infrastructure, workforce supply, performance, quality improvement, pressure injury

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The U.S. and U.K. healthcare delivery systems face a crisis of quality, utilization, and costs.[1] The United States spends approximately U.S. $9500 per capita on healthcare, which is more than double compared with most Western countries.[2] The United Kingdom spends comparatively less than the United States, yet 21 of 25 National Health Service (NHS) Acute Trusts operate on a deficit and still the U.K. system falls short on provider supply by £5 billion (i.e., 47,700 physicians and 26,500 nurses are needed to bring up the NHS staffing levels of other countries).[3] Although these healthcare expenditures are intuitively high, efforts to cut costs may not necessarily be the best option. Instead, by investing in skilled labor to develop a strong quality improvement infrastructure, health systems stand to save more in the long run. Skilled labor is expensive and the largest cost component from a system perspective, which comprises 60% of a hospital's budget.[4] This focus is understandable because labor productivity in healthcare is "flat" or "negative," whereas the number of staff employed by hospitals has grown significantly. Nurses comprise the largest component of the hospital labor force, and evidence suggests that more educated nurses lead to better performance. For example, Blegen et al[5,6] identified that higher nurse-bed ratios improved outcomes, as well as a strong association between higher BSN rates among registered nurses and reduced rates of mortality and nurse-sensitive indicators. Probably, this is why hospitals such as Johns Hopkins Medicine tripled its nursing staff for the past 30 years, although the hospital's bed capacity has not changed.

To reduce labor costs, hospitals approach the following three strategies: (*a*) hire lowest possible skill for the job; (*b*) stretch clinical hours per patient-day; and (*c*) reduce staff not providing direct patient care at bedside.[7] However, these labor constraints designed to reduce costs may paradoxically increase costs. For instance, when intensive care units grow patient volume while holding nursing staff levels constant, or reduce the nursing staff within the existing clinical space, complications and subsequent costs increase.[8] Systematic changes in quality improvement infrastructure require specialty staff who can evaluate and redesign health systems to evaluate the needs of complex patients and prevent complications.

On the other hand, skilled staff who are not solely at the bedside but support improved quality, such as board-certified nurses (e.g., Certified Wound Care Nurses [CWCN]; Certified Nurses in the Operating Room [CNOR]), physical therapists, human factors engineers, and certified quality improvement specialists (e.g., Lean and/or Six-Sigma trained) are generally viewed as hospital costs rather than investments. Unless they can bill for services they provide, they are targeted for cost reduction or unlikely to be budgeted for new services. However, we theorize that having insufficient numbers of these staff may actually increase costs, whereas ensuring sufficient numbers for supporting infrastructure can decrease costs.

Relating Quality Improvement Infrastructure to Outcomes

A quality improvement infrastructure can best be defined as the elements that health systems adopt and invest in to implement clinical best practices more effectively. Nelson et al[9] presented these elements as the following four domains of a best practice framework for quality improvement: leadership; staff; information and information technology; and performance and improvement. Health systems that invest across these domains may improve

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quality, but their adoption patterns should be balanced.[10] Many health systems already have leadership in place, as well as invest in informatics and technology to enhance performance. However, the use of staff is often underestimated or misunderstood in the context of this framework because one would assume that hiring more bedside clinicians solves most problems. However, there are many gradations of staff needed to improve quality, which is where skilled specialists become important. These specialists focus on system planning, educating bedside staff about best practices, and caring for complex patients. It would be difficult to hire a workforce of skilled specialists that is more costly than bedside clinicians or observe their direct impact on patient care when a hospital has the mindset that expenditures on quality improvement infrastructure are costs rather than investments. Thus, the return on investment for spending on infrastructure has to be based on the outcomes that offset the expenses of patient complications.

Figure 1 depicts a conceptual model drawing on the relationship between workforce infrastructure and value, using bedside nurses in combination with certified specialists as an example. This model is based on Weinstein and Skinner's premise that health system quality follows a fixed trajectory until investments are made to adjust its infrastructure, which may be represented by hiring additional bedside staff, but also considering the addition of skilled specialists.[11] Compared with baseline (Y_0), hospitals must first invest more in system infrastructure (Y_1) to reach a point of equilibrium when fewer bedside staff can manage the needs of equally complex patients more efficiently (Y_2) (Fig. 1A). Furthermore, investing in more bedside nurses only yields better hospital quality along a fixed performance curve (Y). On the other hand, by requiring that bedside staff hand-off the complex, high-cost patients to skilled specialists, or depending on these specialists to integrate technologies with bedside practice that save time and improve the accuracy of care delivered can result in performance curve shifts beyond predictable outcomes to achieve greater efficiency (Y') (Fig. 1B).

To test this theory, we studied the relationship between hospitals' CWCNs and the proportion of beds they cover, relative to their associations with pressure injury rates (aka "pressure ulcers," "bedsores").

METHODS

We examined 55 U.S. academic medical centers (AMCs) that reported their data through the Vizient Clinicial Database/Resource Manager ("CDB/RM," http://www.vizientinc.com; then the University HealthSystem Consortium). Academic medical centers reported rates of stage 3, 4, and unstageable hospital-acquired pressure injuries not present on admission on a quarterly basis between 2007 and 2012. The Vizient cooperative of more than 200 AMCs participated in joint data sharing and benchmarking of administrative claims with researchers to improve patient outcomes, quality, and safety.

These longitudinal, deidentified, hospital-level data included counts of hospital-acquired pressure injuries, characteristics of the hospitals (e.g., counts of CWCNs and beds), patients characteristics (e.g., case-mix index [CMI], age, medical versus surgical cases, intensive care unit admissions), organizational quality (e.g., ANCC Magnet recognition, hospital-level adoption of QI interventions pertaining directly to pressure injury prevention, determined through survey of 55 hospitals by Padula et al,[14] 2016), and external influences (e.g., CMS reimbursement reductions for "preventable conditions" such as pressure injuries in 2008).

Data Sources

CDB/RM data on outcomes by hospital-quarter were merged with granular survey data on hospitals' quarterly adoption patterns

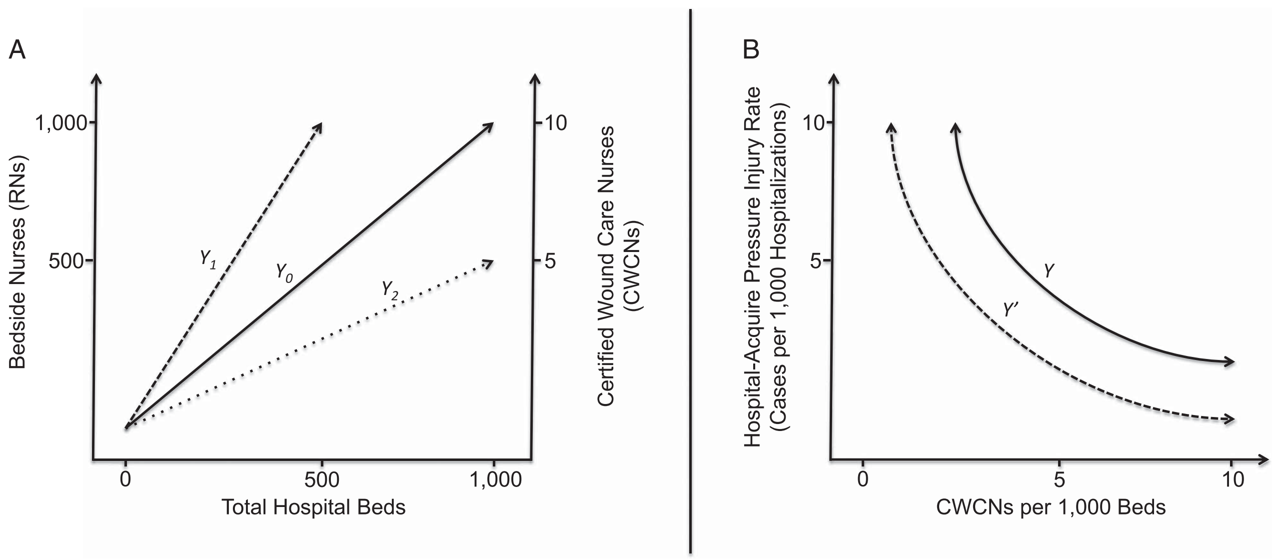

FIGURE 1. Hypothesized relationship between the ratio of bedside staff and hospital volume relative to performance (e.g., safety and quality indicators). For instance, (A) the size of the hospital (total hospital beds) is directly proportional to the number of bedside nurses (RNs) and certified nurses (e.g., CWCNs). Compared with a standard ratio of bedside nurses, Y_0, the nurse-to-bed ratio may shift depending on the perception that an increased investment in infrastructure results in better patient care, Y_1. Alternatively, hospitals that have good structure in place to implement practice guidelines efficiently may be able to operate on a more efficient infrastructure, Y_2, including fewer bedside staff; however, consolidating infrastructure without putting efficient processes in place for guideline compliance can lead to poorer outcomes. B, Our theory suggests that increased investment in hospital infrastructure in terms of skilled specialists is associated with increased performance, such as reductions in hospital-acquired pressure injury rates, Y. Additional investments in technology and other quality improvement programs that enhance the efficiency of nursing performance (e.g., new bed technology) shifts productivity toward Y', but only marginally over a baseline investment to increased staff-to-bed ratios.

of quality improvement interventions across four domains of hospital culture by surveying CWCNs, as described previously.[14] Although the data spanned 2007–2012, not all 55 hospitals were observed during each quarter. More AMCs joined the Vizient database beause the study period progressed from 2007 to get the final number of 55 hospitals by 2011. Hospital-level data only contributed to the analysis as they joined Vizient and shared measures quarterly through the CDB/RM. Inclusion and exclusion periods for each hospital were discussed at length in previously published studies using these data.[8,12–14]

Approach

By managing a panel data set, we created indicators for each hospital quarter between 2007 and 2012. We applied a mixed-effects negative binomial regression model to predict pressure injury rates by quarter, nested within hospitals. The model predicted pressure injury rates using the ratio of CWCNs per 1000 hospital beds, while controlling for the ANCC Magnet status of hospitals (a predictor of nursing quality and being able to attract skilled nurse specialists), CMI (signifying more complex, sicker, patients cohorts being admitted), and whether CMS reimbursement policy for "preventable" conditions including pressure injuries was in effect (after October 2008). We looked at random effects, including a random intercept, because each hospital began at a different pressure injury rate trajectory during the period of observation and would experience differences in rates of improvement based on observed and unobservable factors.

We then compared the relationship between the ratio of CWCNs per 1000 beds in high-performing hospitals versus the low-performing hospitals. We grouped the hospitals into quintiles, first computing mean pressure injury rates within hospitals, and then grouping hospitals on this basis; the 1st quintile represented the lowest-performing hospitals, with the highest mean pressure injury rates; the 5th quintile represented best-performing hospitals. These quintiles were based on averages over time, such as how CMS calculates these categories.

RESULTS

Actual improvements in pressure injury rates were observed aligning with our theory in AMCs, knowing that board-certified CWCNs cannot be at the bedside to meet every patient's wound care needs (Table 1). We also witnessed that although the 1st and 2nd quintiles and the 4th and 5th quintiles were fitted on two parallel curves, the 3rd quintile did not fit either of these curves and could be hypothesized to lie on a separate, parallel curve.

TABLE 1. Average Number of CWCNs Per 1000 Hospital Beds in AMCs in the United States, Stratified by Performance Quintile According to Hospital-Acquired Pressure Injury Rate*

Average No. CWCNs per 1000 Beds	3.8†
CWCNs per 1000 beds by pressure injury rate quintile	
First quintile (0%–20%)	5.88
Second quintile (21%–40%)	3.56
Third quintile (41%–60%)	5.47
Fourth quintile (61%–80%)	6.81
Fifth quintile (81%–100%)	5.44

*AMCs in the 1st quintile represent the lowest performers (i.e., high or poor rates of pressure injury), and the 5th quintile represents the highest performers (i.e., low or exceptional rates of pressure injury).

†Adjusted for case-mix index and ANCC Magnet Recognition.

Figure 2 illustrates this trend further based on statistical analysis of outcomes associated with specialist-bed ratios. On graphing the boxplots and arranging the Y-axis, so that it proceeds from best- to worst-performing quintiles, we superimposed smoothed Lowess curves to connect the means of these quintiles and explore shifts in the CWCN-bed ratio when moving from one quintile to the next. Based on the trend in this figure, highest performing hospitals with respect to pressure injury rates seemed to be going through the process of investing in prevention infrastructure with CWCNs, if the theory by Weinstein and Skinner holds true to this example.

Our statistical model indicated that the addition of one CWCN per 1000 hospital beds was associated with a 17.7% decrease in pressure injury rates from the previous quarter, controlling for other factors (Table 2). None of the QI interventions based on the best-practice framework were found to be statistically significant covariates when controlling for CWCN-bed ratios. Coinciding with these data was a recent payment policy from CMS that began penalizing hospitals 1% of their total reimbursements, which fell in the lowest-performing quartile with respect to composite rates of hospital-acquired conditions, known globally as Patient-Safety Indicator #90 (PSI90). Again, the highest performers seemed to have overcome poor rates by investing in an infrastructure of skilled specialists if the theory by Weinstein and Skinner is actual under these circumstances, but these high performers supplied fewer CWCNs per 1000 beds and still reduced pressure injury rates.

DISCUSSION

Is it possible to reduce spending without adding workforce or expecting fewer clinicians to manage the same volume of patients? In the long run, yes. Maintaining skilled specialists in place with training to implement and disseminate evidence-based strategies for improved hospital quality can help bedside staff care for patients more efficiently. However, the bandwidth to overcome existing organizational challenges that hinder better performance requires upfront financial investment in a larger workforce infrastructure configured to institutional needs. This workforce, forming a team combining bedside clinicians, quality improvement as well as technical support and other types of clinical specialists (e.g., certified nurses and therapists) can improve quality and reduce costs.[15,16]

Some AMCs seemed fortunate to invest in their staff education and hire more CWCNs to achieve harm reductions. The poorest performing hospitals had lower ratios of CWCNs, whereas the 4th and 5th quintiles represent high performers who have overcome structural inefficiencies by maximizing the specialist-bed ratio and potentially resystematized the implementation of evidence-based guidelines to become more efficient at keeping patients safe.[14] The 5th quintile of hospitals had lower specialist-bed ratios than the 4th quntile as a result, such that our real-world data validate the theoretical model in Figure 1 that the high-performing hospitals operate more efficiently with a more powerful infrastructure in place.

It is extremely difficult to convince hospital finance directors to make upfront investments in skilled labor that does not always bill for patient care. These investments can deplete cash resources quickly if investments are not well planned. However, there is likely return on investment for these skilled specialists based on our initial knowledge that spending on a safety infrastructure is cost-effective compared with treating downstream adverse events of hospital care, such as pressure injuries and bloodstream infections.[17–19] These incidents lead to extended hospitalization, occupy many bedside clinicians' time, are not reimbursed by payers, and lead to malpractice lawsuits in the millions of dollars. By learning from the experience of high-performing facilities that, for instance, indicated 3.8 CWCNs per 1000 beds is only the average hospitals, which make an additional upfront investment in skilled specialist

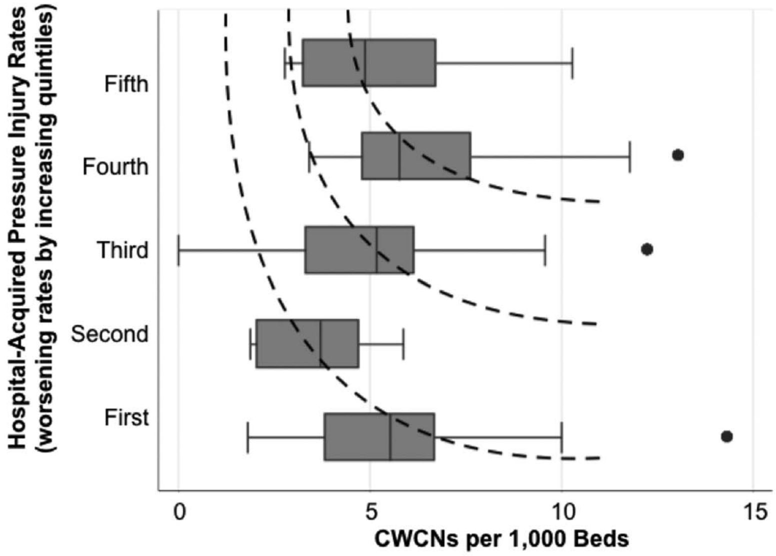

FIGURE 2. Boxplots of the mean and 25th- to 75th-percentile range of CWCN-bed ratios in AMCs by quintile of pressure ulcer rates, along with outliers represented dots outside of the 95% confidence interval. Overlayed Lowess smoothed curves illustrates the trend of increasing workforce infrastructure with CWCNs between the 1st to 2nd, 3rd, and 4th to 5th quintiles, noting that the highest performing interquintile space is able implement pressure injury prevention strategies with greater efficiency (i.e., fewer CWCNs per 1000 beds).

infrastructure are likely to achieve a return on investment by not paying for these adverse outcomes, which are costly and lead to payment penalties.

What can health system stakeholders learn from these data? The NHS of England may be exhibiting one of the best efforts to transform its health system quality with investments to infrastructure through The King's Fund.[20] Through this program, the United Kingdom is investing £22 billion in health system infrastructure strictly to improve quality through 2021.[21] A key component of The King's Fund directive is that improvements in quality are centered within Sustainability and Transformation Plans (STPs) so that health systems of the NHS can transform their system as prescribed by the STPs to achieve improved quality in health domain of healthcare delivery and receive payments for these improvements.[22]

Rather than making centralized investments in infrastructure as the United Kingdom intends, the U.S. CMS has reformed payment incentives multiple times in the past decade to reduce reimubrsements for adverse events in hopes of stimulating hospital-level investments in quality.[23] However, CMS policy has yielded in mixed results, such as improving trends for some patient outcomes (e.g., infections) and worsening trends in other areas (e.g., pressure injuries).[24] The issue with a nonpayment model or penalties for poor outcomes as CMS has prescribed is that poor performing hospitals never have the bandwidth to reinvest revenue in infrastructure because they are constantly playing catch-up to the costs of care.

If CMS is to innovate a next-generation payment model for U.S. safety indicators, such as pressure injuries and infections, perhaps a model that offers the opportunity to obtain investments from the central body such as the United Kingdom, has done is necessary. A two-sided risk model that pays hospitals a proportion of the upfront-cost of prevention and rewards hospitals retrospectively for improved performance is what hospitals need to cross the chasm between *Y*and *Y′* in Figure 1.[25] Likewise, two-sided risk gives CMS the opportunity to recover loses where hospitals do not efficiently use the payments. The NHS' STP model also dictates that CMS would require facilities to develop an infrastructure around a prescribed structures (i.e., Centers of Excellence), such as containing more than 3.8 CWCNs per 1000 beds and exhibiting compliance with guidelines.[26,27]

TABLE 2. Relationship Between Hospital-Acquired Pressure Ulcer Rates and the Ratios of CWCNs to Beds, While Controlling for Other Hospital Factors

Pressure Ulcer Factors	Coefficient (95% CI)	P
CWCN	0.404 (0.13 to 0.67)	0.003
Beds	−0.002 (−0.003 to −0.001)	0.033
Ratio of CWCNs per 1000 beds	−0.177 (−0.31 to −0.04)	0.009
Magnet status	−0.445 (−0.72 to −0.16)	0.002
Case-mix index	0.634 (0.33 to 0.94)	<0.001
CMS policy	−2.176 (−2.29 to −2.06)	<0.001
Intercept	−5.248 (−6.27 to −4.23)	<0.001
Variance (intercept)*	0.266 (0.17 to 0.41)	<0.001

Coefficients were derived from a mixed-effects negative binomial regression model with random intercept measuring pressure injury rates between hospital quarters from 2007 to 2012.

Log likelihood (goodness of fit) = −2153.52.

*A random intercept model was selected over a fixed effects model by way of the Hausman test.

CMS policy, decreases in reimbursement for hospital-acquired conditions in October, 2008; magnet status, hospital designation in the ANCC Magnet Recognition Program.

Limitations

This analysis had multiple limitations. First, the use of PSI03 from administrative claims data risks underreporting of unbilled pressure injury cases. Meddings[28] notes that surveillance data are preferable to claims data for the purpose of tracking pressure injury performance. Nonetheless, our analysis was focused on powering the association between nurse-bed ratios and high performance over time between many hospitals, which necessitated the use of administrative claims. Second, the correlation observed between nurse-bed ratios and high performance is probable based on the statistically significant results of the multilevel regression model, but not certain. Other statistical methods typically used to overcome issues relating to causal inference, such as instrumental variable analysis or propensity score matching, were not possible given the data available for this study. The multilevel variable analysis provided the best available method to measure association that gives the data structure. Third, other factors uncontrolled for in the regression analysis may modify the effects of skilled specialists on pressure injury rates beyond the ones observed in this study; however, past research has not found other factors to have statistical significance and were therefore omitted.[14] Fourth, the role of the CWCN in each hospital's quality improvement infrastructure may vary with respect to pressure injury prevention.[29]

CONCLUSIONS

Ultimately, skilled specialists bring important value to health systems as a representation of investment in infrastructure and that the proportion of these specialists is could be scaled relative to the hospital's patient capacity. This observation is significant on a number of levels. First, it demonstrates a relationship between skilled specialists and quality improvement. Second, it underscores the importance of a strategic and targeted relationship between workforce configuration and outcomes. The next iteration of government policy that supports hospitals to make up-front investments in infrastructure to drive down patient costs and improve quality is likely one that is needed for many hospitals to achieve the results that few AMCs and other facilities have been fortunate to observe.

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